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ABSTRACT

The National Science Foundation financed a project enabling 10 small, nonresearch colleges to purchase minicomputers for academic and administrative use. The purpose of the study was to determine whether an owned minicomputer is a better investment for such small colleges than a time-sharing system or a cooperative arrangement. The colleges purchased Digital, Hewlett-Packard, or Data General computers and support hardware and software. The project, which began in 1970, is not finished, but preliminary results indicate that there is a great preference for the minicomputers, and that they have provided satisfactory services for much lower cost. The college found that one full-time person's effort was needed to operate and sustain the systems and that the 16-bit word length is preferred over the 12-bit. In addition, the computing capacity of the minicomputers was reasonably comparable to larger machines. (WH)

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THE MINICOMPUTER AS SUPPORT FOR ACADEMIC COMPUTING REQUIREMENTS

- a preliminary look at some results of an NSF-supported - - experiment to evaluate minicomputer use -

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Colleges and Universities which do not emphasize research activities have been struggling for several years with the costs of providing academic computing facilities. As more freshmen arrive with prior computing experience, more graduate schools require background employing computers as prerequisite to admission in some programs of study, and an increasing number of undergraduate programs require use of a computer, there is increased pressure to provide access to a computing facility. Unfortunately, the traditional academic computing center is generally an impossible financial burden without a workload of research computing to justify its existence.

During the late '60's a number of different approaches were attempted which centered on ways to share computing resources. Two principal methods evolved: interactively "time-sharing" access to a large computer, or cooperatively sharing a computing facility within a small geographical area. Both methods were the subject of a number of NSF-supported experiments, and each suffered some drawbacks. Interactive use somehow didn't generate the anticipated interest at many institutions, possibly because of the limited availability offered by only one or two terminals. Shared facilities favored the institution where the computer was located, and interest and use at the other cooperating institutions suffered. As a third approach some institutions opted for a small computer, financially justified by sharing administrative data processing and academic workloads on the same computer. An experiment comparing the above three methods was conducted over a two-year period beginning in 1968 by the Southern Regional Education Board with NSF funding. Nine institutions used time-sharing terminals to a variety of GE, IBM, and CDC computers, five institutions shared a common computer, and six institutions obtained computers to support combined administrative and academic computing needs.

As a result of this experiment the average institutional expenditure per registered student attributed to the instructional uses of a computing service was calculated to be $19 per year for terminal access (using one or two ASR33's or one IBM 1050 terminal), $13 per year for access to a shared computer, and $20 per year for the instructional fraction of an average $36 per year for a small institutional computer.

During the course of the above experiment, the mini-computer market expanded into the educational market. By late 1969, several mini-computer vendors were claiming the ability to support educational computing needs at a lower cost than one terminal's access to a time-sharing service. The ability to control operations, access, and systems changes to one's own computer, while providing computing facilities at a price that even the smallest colleges could afford was appealing. However, there was a natural reluctance on the part of most institutions to risk the investment needed to acquire a mini-computer and to maintain the system. There was also a concern about the ongoing support commitment of faculty release time and perhaps staffing. In addition,

the colleges most in need of computing equipment generally lacked people with background and experience useful in selecting a suitable mini-computer configuration. The National Science Foundation, in 1970, funded a project which in effect shared the financial aspects of the small college risks involved in obtaining mini-computers for ten institutions. The institutions selected, and the mini-computers acquired, were of different sizes and types. The purpose of the project was a general evaluation of various types of mini-computer systems used in support of academic computing needs.

It should be appreciated that mini-computer systems vary widely in configuration, and can differ in mode of use. In the batch mode, a system may have a high-speed card reader, similar to any major computer, or a lower priced optical reader capable of reading punched holes or marks at fairly slow speeds. The output printer may be simply a teletype, or a range of slow to fast printers. In the interactive mode, systems were generally configured to accept anywhere from one to perhaps sixteen terminal ports. Memory sizes available in 1970 typically ranged from 4K to 32K words of 12-bit or 16-bit length. Secondary memory was available via magnetic tape cassettes, disks, or drums. The combinations of hardware systems available were as complex to evaluate as any major computer system. Software support, particularly as early as 1970, was very difficult to assess.

The NSF had helped support many computing installations since 1956. This project was uniquely different, however. Previous grants were invariably awarded after assurance of technical capabilities at the institutions. In this project, however, it was desirable to experiment with inexperienced personnel in order to evaluate systems in a setting common to many small colleges. The purposes of the project emphasized reporting information so that other institutions might benefit by the experiences of the ten experimental colleges. A program of semi-annual meetings of representatives from the colleges was arranged. This permitted an active interchange of experiences and ideas. In addition, a consultant, the author, was engaged to regularly visit the various campuses in order to document subjectively the experiences with the mini-computers, and also to assist with problems. Overall administration of the project, including objective reporting, was accomplished through a grant awarded to the Southern Regional Education Board, with Dr. John Hamblen as principal investigator. (Dr. Hamblen is now with the University of Missouri, and is completing his reporting as a consultant to SREB).

The ten colleges acquired mini-computers from three vendors, Digital Equipment Corporation, Hewlett-Packard, and Data General. Hardware costs ranged from about $20,000 to $100,000 for small to medium-size batch systems, and one to 12-port interactive systems. The participating institutions, with their initial computer configurations were:

Benedict College: (1500 students)	DEC PDP-8/I-D, 12K core 250K Disk 4 - ASR33 terminals
Canisius College: (4100 students)	Data General Super Nova, 16K core 256K Disk 4 - ASR33 terminals
Delaware State College (1800 students)	DEC PDP-8/I, 4K core 32K Disk Optical Card reader
Erskine College: (700 students)	DEC PDP-11, 16K core 256K Disk 4 - ASR33 terminals
Hollins College: (1100 students)	DEC PDP-8/I-D, 16K core 256K Disk 6 - ASR33 terminals
Macmurray College: (900 students)	Hewlett-Packard 2116B, 16K core 492K Drum Mag Tape 8 - ASR33 terminals
Maryville College: (850 students)	Hewlett-Packard 2114B, 8K core 2 - tape cassette transports Optical Card Reader
Mt. Union College: (1300) students)	Hewlett-Packard 2116B, 16K core 1,240K Disk 300 LPM printer High-speed card reader
Illinois Benedictine College: (1000 students)	Hewlett-Packard 2114B, 8K core 1,600K Disk Optical Card Reader 2 - ASR35 terminals
Univ. of the South: (940 students)	Data General Nova, 8K core Optical Card Reader

The experiment began in the Fall of 1970 and extended officially through August, 1973. The reporting process is now underway, with the findings of the project expected to be published in the Spring, 1974. This paper does not constitute an official report of the experiment, however, some points of interest have been noted by the author.

Operations

The proposals from the colleges initially indicated 25% release time of one faculty member would be provided to administer the facility. This was universally insufficient, with the result that anywhere from half-time (with assistants) to one full-time person's effort has been provided to satisfactorily provide service.

Hardware

The equipment has been generally reliable, especially the major components from Hewlett-Packard and DEC. About half the installations have elected not to use a service contract, since the equipment fails so rarely that on-call charges are much cheaper. Exceptions are the mechanical components, especially optical card readers. If they had it to do over, most institutions would opt for more and better I/O components. Some would also favor more disk or tape capacity. A 16-bit word is preferable to 12-bit word length.

Software

The best regarded software seemed to be from DEC, with favorable comments about Hewlett-Packard. It should be understood that Data General had just entered the market at the outset of the project, and their SUPERNOVA and NOVA machines were very near the prototypes. The major advantage to DEC software stems from the large number of other installations with programs and advice.

During the project, all vendors involved went through several generations of BASIC and FORTRAN systems. The final report of current offerings will probably be most useful as a guide to software quality.

Cost and Service Comparisons

Four of the institutions had previously used an interactive time-sharing service, and two had used formal arrangements with nearby major computer facilities. Costs were considerably lower for terminals to the mini-computer than prior time-sharing costs. One institution had spent $16,000 on the previous year's time-sharing service, and now provides two terminals plus optical card reading on a system purchased for under $30,000. All institutions favor their own system, which they feel enables them to design in their own needs, is more reliable, and offers a valuable degree of control. In addition, there is somehow a psychological attractiveness, exhibited by faculty, students, and administrators, to having an institutional facility. Also mentioned was a sense of security; two institutions noted that their former suppliers of computer service had folded.

Some Comparisons with a larger system

Speed specifications for mini-computers often appear to be highly competitive with large-scale computers which cost much more. For example, the memory cycle time of an IBM 360/65 is 0.75 microseconds, while the cycle times for representative mini-computers are:

Hewlett Packard 2116B:	1.6 microseconds
Data General Supernova:	0.8 microseconds
DEC PDP-11	0.9 microseconds
DEC PDP-8	1.2 microseconds

A simple benchmark program was run using the various mini-computers, with the software system that happened to be used normally at the various installations. For comparison the same program was also run on a few other computers using on-going software. Accuracy of results and number of executions per minute of one of the steps in the basic loop were tabulated. The gross results were:

Computer	Language	Digits Accuracy	Executions/sec
PDP-11	BASIC	7	16
Supernova	BASIC	5	67
HP 2116	BASIC	6	29
IBM 1130	FORTRAN	5	67
IBM 360/65	(a) CPS BASIC	14	120*
	(b) CALL/360 BASIC	5	330*
	(c) WATFOR FORTRAN	5	1000
	(d) FORTRAN G	5	2500

*run using IBM LCS, reducing cycle time to 8.0 microseconds.

These comparisons, using circa 1970 systems, must not be interpreted too literally. Certainly, the software in use, and its applicability to a given program, will influence timing greatly. A general observation may be drawn from this example, which looped through an expression calculating:

ABS (SIN(FLOAT(I) * .1)) ** .3/5.2
(where I is an integer ranging 1 to 1000)

The problem employs floating point calculations and uses several functions, which are obviously handled faster on the large-scale computer with floating point hardware and more speedily accessed function routines. Thus "large-scale" type computing, such as many research problems, will probably be cumbersome or impractical to run on a mini-computer. For the instructional applications of the institutions involved, the slow floating point computations were only occasionally a problem.

An extensive report, giving specific results of this project, should be published for the NSF by April, 1974. It will include details on hardware configurations and changes, languages used, mode of operation, workload processed, costs, academic applications, and other related information.